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test this question, if somebody would plant an infant pine and oak together near a grown oak, and the same near a grown pine. There should be several of each plant to guard against accidents to either kind spoiling the comparison, and then observe their comparative progress a few years. Has anybody ever done this? Will somebody who has an opportunity please do so?

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BUFFALO AND CHICAGO, OR "WHAT MIGHT HAVE BEEN."[1]

BY PROFESSOR E. W. CLAYPOLE.

THE great spectacle which Buffalo can show to the members of the association needs no description. Met as we are, almost within sound of the cataract, we are tempted to ask concerning it many questions, to answer which would not be easy. But to us who compose the Section of Geology, Niagara is a study of peculiar interest. The structure and age of its rocks, the formation of the great gorge and the various causes that have combined to produce it, all these topics have received careful consideration, and though our queries are far from being fully answered, yet the partial replies already extorted from nature are deeply interesting and strongly suggestive.

Most of these points are, however, familiar to geologists, and I do not therefore propose to dwell upon them. They have already claimed and will again claim our attention. But there is one, both curious and interesting, to which I wish to refer for a few minutes.

In the study of history it is often both entertaining and instructive to stop in one's regular course, and dropping the thread of the narrative of actual facts, to consider what might have been the course of events had certain great and critical occurrences not happened at all, or happened in a different manner or under different conditions. These "might have beens" of history, though of course impossible, are not necessarily useless to the student. A consideration of some of them sometimes shows us on how slender a thread have depended most momentous results. The delay of a few hours, the failure of an apparently unimportant coincidence would in many cases, so far as we can see, have changed the whole current of subsequent events to whatever extent those events were dependent upon them. And in like manner in geology, by stopping to think, not on what has happened but on what might have happened, we sometimes discover a whole train of consequences flowing from some apparently insignificant cause which might seemingly just as well have happened differently or have not happened at all. To one of these geological " might have beens" I venture to ask the attention of the section to-day, in the hope that it will not be quite without interest, seeing that, as I have already said, we are met on this classic ground in a city whose destiny—whose very existence I may say—was determined by the possibility to which I wish to allude.

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[1] A paper read in abstract before the Geological section of the A. A. A. S. at Buffalo, August, 1886.

The Great lakes of North America are one of the most singular hydrographical features on the surface of our earth. A great part, perhaps nearly a half of all the fresh water on the planet, is dammed up on the top of a table land between five and six hundred feet above the sea. At least this is true of the four upper members of the chain, Erie, Huron, Michigan and Superior. The long irregular rim surrounding this great inland sea varies in height from 1500 feet above tide down to the lake level. Of course in so long a water-shed there are many low places. But with most of these we have no concern.

There are, however, two of these low places that involve interesting geological possibilities. These are Buffalo and Chicago. Buffalo is the outlet port and Chicago is the port at the head of lake navigation. The relationship of these two cities to one another is not accidental or determined by man, it is based on geological causes over which man has had little or no control. Yet a geological study of the region shows us that solid as is the base on which stand the destinies of these two cities, there yet have been critical epochs in the development of the lake district when a very slight difference would have been sufficient to change, even to reverse their relations to one another.

II.

The channel of the Niagara river at Black rock of course marks the present lowest point in the water-shed or rim of the lake basin. It also proves that this was the lowest point when the flow of the Niagara river began. Any one who has been down to the outlet has observed that the land on both sides is flat and raised only a feet feet above the water. Now Lake Michigan is only ten feet above Lake Erie, and the land behind Chicago is not more than twelve feet above Lake Michigan on the water-shed between it and the Mississippi basin. This low place on the river is therefore less than twenty-five feet above the water level at Black rock. It follows then that a dam of that height across the river at Buffalo would stop its flow and throw the stream over the low ridge at Chicago into the Des Plaines and the Mississippi. In like manner a cut sufficiently large through this ridge would drain off the water and leave Niagara dry. Chicago would then be the outlet and Buffalo would lie at the head of lake-navigation. Such is the delicacy of the natural adjustment that has determined the relation of the two cities. We may liken the lakes to a fountain-basin having two notches in its rim of about the same depth. The slightest tilt may suffice to throw all the waste water over either of these notches and leave the other dry.

But a dam of the size imagined would be a task of vast magnitude. This is true if regarded as a work of human engineering. But we all know that at no distant date, geologically speaking, the whole region in question and much more of the northern part of the country was covered with a sheet of ice, and that this ice moved immense quantities of earth, sand and stone from place to place, depositing them far from their previous resting spots. Sometimes this great transporting agent dropped its load of wreckage in long lines across the country, as may be seen in the great terminal moraine recently traced from Long island nearly to the Rocky mountains by the labor of Wright, Lewis, Chamberlin, Upham and others. In other places these moraines are less extensive and bulky, though equally evident. They vary in height from ten or twenty feet to three or four hundred feet, or even more, and in breadth from a few yards to several miles.

Now let us in imagination suppose that the retreating ice had dropped one of these moraine lines across the course of the present Niagara river, near the place of its outflow from Lake Erie, as it dropped them in many other places. The possibility might then be realized. Had one of the ridges so common in Northern Ohio been formed at Black rock, the Niagara river might not have begun to flow, and the ultimate outflow of the lakes might have been by Chicago.

III.

But this is not the whole story. Things were not always as they now are. If the equilibrium in the drainage of these lakes is now so delicate, there was a time when it was more delicate still, and when no man could have determined in which direction the outflow would ultimately go. There was a time when the whole northern part of the continent was covered with ice. As the climate grew warmer this great ice-sheet drew back. Its edge retreated northward slowly exposing the underlying ground. In this way Lake Erie and adjoining country were step by step freed from their icy covering. When the ice had melted sufficiently the Niagara river began to flow. Into all the details of its early course I cannot enter. Many of them are still uncertain. But there came a time when the level of Lake Ontario was lowered sufficiently to allow the water to pass into it from Lake Erie. Then the Niagara river was born and the direction of the lake drainage established. Then began the flow of the most beautiful river of the continent, the St. Lawrence, with its clear green water, seldom sullied, and its almost unvarying level both in summer and winter.

Now there is ample evidence that in former days the level of the Niagara river was much higher than it now is. Professor Hall has pointed out in his " Geology of New York," and Sir C. Lyell in his " Principles of Geology," the existence on Goat island and at various points along the river of alluvial strata containing recent shells. Terraces consisting of this material skirt the stream for a long distance, and rise in some places forty or fifty feet above the water. The fineness and softness of these deposits shew that they were laid down in still or slowly flowing water. The highest beds are nearly on a level with the surface of the lake, and they were of course at the bottom of the water at the time of their deposition. Hence it may be inferred that the lake and river both stood then higher than now. It would appear that at the time when these beds were deposited with their contained shells, an arm of the lake or else a very sluggish stream must have extended northwards along the present channel of the Niagara, of course before the excavation of the gorge or the full development of the cataract. Considering this fact we are compelled to ask where was the dam that held back the waters so that they were able to deposit sediment so far above their present level. To this question only one answer seems possible. The dam was the ridge of Queenston heights, now forty feet above the lake-level. Here is a barrier sufficient to confine the water till it reached the required height.

But the objection naturally rises: If the crest of the Silurian escarpment at Lewiston is forty feet above Lake Erie, how could the river take its course in that direction and not over the Chicago ridge fifteen feet lower?

Three answers are possible.

1st. The point at which the river crossed the ridge must have been rather lower than the adjacent portions. A stream always chooses the lowest ground. Now it is just possible that this point was so much below the rest of the ridge that it was lower than the notch at Chicago, and therefore determined the outflow in the northeasterly direction. This, however hardly amounts to a probability, and certainly deserves no more than mention.

2d. Most geologists are agreed that during the ice age the northern or north-eastern part of the continent was depressed much below its present level—in some places many hundred feet below it—and that as the ice age passed away it slowly recovered nearly its former elevation. The presence of recent arctic shells on the tops of hills, as at Mount Royal, Montreal, is decisive proof of this. I will not now discuss the cause, it does not concern the subject. But in view of the fact that the ridge at Queenston is far to the east and somewhat to the north of Chicago there is nothing improbable in the supposition that it was lower in depression and later in reëlevation. Hence at the time in question it may have been so far below its present height as to have been actually the lower of the two, and have thus determined the outflow of the water by the ordinary laws of drainage. If then the river was capable of cutting it down by erosion as fast as it rose by continental elevation, the channel once established would be permanently maintained. And there is no reason to doubt the competency of the Niagara to accomplish this task.

3d. But there is a third and a more likely answer yet. The slow northward retreat of the ice exposed the southern and southeastern portions of the country first, holding the north and northwest covered till a later time. Hence the conclusion is unavoidable that after the Niagara district and Central New York were free and the northern or eastern outlet opened, the channel at Mackinaw was still ice-locked and no communication was therefore possible from Lake Erie to Lake Michigan. The water was thus ponded back and could not flow over the low dam at Chicago because of the existence of a high ice-dam at Mackinaw. It was therefore compelled to rise until it was high enough to overflow at the next low point—the ridge of Queenston—at whatever height that ridge may then have stood.

IV.

The relationship then of Buffalo and Chicago as the outlet and the head of lake navigation depends on a series of geological changes whose results are so nearly in equilibrium that at certain epochs a trifle would have been sufficient to reverse them. As with some of the lakes and streams in Northern Ohio, the breaking of a dam or the cutting of a ditch is enough to divert into the Mississippi water that previously flowed into the St. Lawrence.

Summing up the result above obtained, we find that the Niagara river would probably never have existed and that the drainage of the four upper lakes would have flowed past Chicago into the Mississippi,

(1) If the ground at Black rock had been about twenty-five feet higher when the river began to flow.

(2) If the ridge behind Chicago had been lower by the same amount.

(3) If the Silurian escarpment at Queenston had been as high as it is at present.

(4) If the reëlevation of the land after the ice age had been more rapid.

(5) If the ice-dam at Mackinaw had melted before that to the north and east of the lakes.

In any of these cases it is probable and in some of them it is certain that the water now flowing by Black rock would have gone through Illinois. Buffalo would have been Chicago and Chicago would have been Buffalo.

A long series of consequent changes of other kinds would have resulted from the reversal of the relationship between these two cities. The course of the discovery and development of the country could hardly have taken place along the same lines, and the great highways of traffic and communication, especially in early days, would have taken different directions. But the following out of these subjects is not within the province of a geological paper.

NOTE.—Since the above paper was written I have been favored by the courtesy of Mr. O. Guthrie, of Chicago, with a copy of the Report of the Committee on the Drainage of Chicago, and a letter containing some further interesting details upon the subject. From these data I learn that the low ridge behind Chicago, mentioned in the above paper, has a breadth of only five miles, and that a scheme is on foot for cutting a canal or a channel through it to the Des Plaines river in order to carry away the sewage of the city entirely from L. Michigan, and avoid the contamination of the water-supply, whose purity is now seriously endangered by the flow of drainage into the lake not far from the crib, during floods in the Des Plaines river.

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THE ARTHROPOD EYE.

BY J. S. KINGSLEY, SC.D.

THE year 1886 has already seen several important studies upon the eyes of Arthropods, some of which have materially altered our conception of the organ and of compound vision. Of these studies by far the most important are those detailed in Dr. William Patten's "Eyes of Mollusks and Arthropods" (Mitth. zool. Stat. Neapel, VI, pp. 542-756. pls. XXVIII-XXXII, 1886). The paper is far too long for complete abstract here, but some of the more important points relative to the compound eye may be useful in supplementing the statements in the manuals of comparative anatomy. Incidentally it may be remarked that the matter pertaining to the eyes of mollusks is equally valuable.

As described in our hand-books, our knowledge of the eyes of Crustacea, spiders and insects is based on Grenacher's classic "Sehorgan der Arthropoden" (1879), and no one (Graber excepted) has ventured to criticise his results. Not so Dr. Patten. He has shown that Grenacher is wrong in many fundamental points, and that his conception of these organs is in some respects so erroneous as to be all but worthless. The writer, in passing, may remark that he has had occasion, in studies in a somewhat different direction, to verify many of Patten's statements, and so far as he has gone he can confirm them. The figure of one of the elements of the eye of the shrimp, illustrating this article, is drawn from his own preparations, but in all essential features it agrees well with similar figures of the eyes of other Crustacea given by Patten. The